ADEQUACY OF SEISMIC MARGINS ASSUMING AN INCREASE IN AMPLITUDE OF THE DIABLO CANYON LONG TERM SEISMIC PROGRAM HORIZONTAL GROUND MOTION IN THE FREQUENCY RANGE BELOW 2.5 HERTZ

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PG&E Pacific Gas and Electric Company

Diablo Canyon Power Plant
Long Term Seismic Program

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As requested in an NRC meeting summary dated March 22, 1991, following is a discussion of the effects on Plant structures of an increase of 10 to 15 percent in amplitude of the Long Term Seismic Program 84th-percentile site-specific horizontal ground motion spectrum in the frequency range below 2.5 hertz. No essential equipment or components have fundamental frequencies lower than 2.7 hertz; therefore, an increase in the spectrum in the frequency range below 2.5 hertz would have no effect on the seismic margins of essential equipment and components.

The structures that could potentially be affected by an increase in horizontal ground motion amplitudes below 2.5 hertz are made of structural steel and have fundamental frequencies below 2.5 hertz. At Diablo Canyon, these structures include:

- Pipeway structure
- Fuel handling building superstructure
- Overhead cranes, such as, dome service crane, polar crane, and intake gantry crane
- Tanks (sloshing mode)
- Turbine building superstructure

Pipeway Structure

The pipeway structure is a Design Class I (typical) steel frame structure whose main function is to provide support, including pipe whip restraints, for the main steam and feed-water pump lines between the containment and the auxiliary building. As a result, the pipeway structure is designed to resist large forces from postulated pipe ruptures, as well as seismically induced forces. Because the effects of postulated pipe rupture far exceed seismic demands, an increase of 10 to 15 percent in the 84th-percentile site-specific horizontal ground motion spectrum at frequencies less than 2.5 hertz would have an insignificant effect on the seismic margin for the pipeway structure. The structure would continue to have a substantial seismic margin.

Fuel Handling Building Superstructure

The fuel handling building superstructure is a Design Class I steel frame structure. The main function of the building is to enclose the fuel handling area of the auxiliary building and to support a large overhead crane used in fuel handling operations. The building, when reevaluated for the Hosgri earthquake, underwent significant modifications, notably of connections, to satisfy the requirements of Design Class I criteria, and also 1969 AISC Specifications.

The fuel handling building superstructure has a fundamental frequency of about 1.5 hertz in the east-west direction. The building consists of east-west structural bents connected by horizontal roof diaphragms. This structural arrangement provides a mechanism that effectively allows necessary redistribution of forces in the event of yielding of any of the framing members. Additionally, the design is highly redundant, and therefore the structure possesses enhanced energy absorption capabilities; however, the benefits from the effects of inelastic energy absorption were not considered in the design evaluation. As a result, the fuel handling building superstructure would continue to have a substantial seismic margin given an increase of 10 to 15 percent in the 84th-percentile site-specific spectrum at frequencies less than 2.5 hertz.

Overhead Cranes

Overhead cranes are typically welded or bolted steel structures that are designed to meet Design Class I requirements. These provisions, in addition to providing stringent requirements, also include evaluation of crane structures to resist a load combination caused by a rated lifted load concurrent with horizontal and vertical components of the Hosgri earthquake. Because the lifted load is very large, loads in the vertical direction generally control the design; the horizontal seismic loading provides a lesser contribution. Because large lifts approaching the rated capacity of a crane occur very infrequently, the design basis load combination is conservative. In addition, the beneficial effects of the energy absorption capability were not considered when applying Design Class I criteria. For these reasons, the seismic margin for overhead cranes will remain adequate given a 10- to 15-percent increase in 84th-percentile site-specific spectral acceleration in the frequency range below 2.5 hertz.

Tanks (sloshing mode)

Some of the outdoor storage tanks are affected by the sloshing mode of the contained fluid at very low frequencies. The contribution of this type of dynamic effect to the overall seismic response of the tanks, however, is very small. Thus, a 10- to 15-percent increase in 84th-percentile site-specific spectral acceleration at low frequencies would have a negligible effect on the seismic margin of these tanks.

Turbine Building Superstructure

Figure 1 shows that the spectrum used for evaluating the turbine building during the Hosgri reevaluation exceeds the postulated increased spectrum in the frequency range of interest. Therefore, the seismic margin of the turbine building superstructure will remain adequate given a 10- to 15-percent increase in the 84th-percentile site-specific spectral acceleration in the frequency range below 2.5 hertz. During the Hosgri reevaluation, the input spectrum used for evaluation of the turbine building was derived by increasing the applicable design spectrum by 10 percent to account for torsion resulting from geometric eccentricity and other effects associated with ground motion incoherency. It can be seen that, in the range of east-west fundamental frequencies, the 10-percent-higher turbine building spectrum (qualifying input level for the structure) envelops the 84th-percentile site-specific spectrum increased by 15 percent (Figure 1).

The turbine building superstructure consists of a steel framing system having east-west roof trusses and braced frames in the north-south direction. A bracing system at the lower chord level of the roof trusses provides a diaphragm for lateral load distribution. Fundamental frequencies for the superstructure are 3.3 hertz in the north-south direction, and range from 1.26 to 1.53 hertz in the east-west direction, depending on the position of the turbine building crane structure with the lifted load. The steel framing system in the east-west direction is highly redundant, therefore it possesses enhanced energy absorption capabilities. During the Hosgri reevaluation, a small amount of local ductility was allowed; however, the structure possesses significantly larger inelastic energy absorption capability. This capability, in turn, will allow redistribution of loads and a consequent increase in the overall seismic resistance of the structure. The seismic margin of the turbine building superstructure will remain adequate for a 10- to 15-percent-higher horizontal input motion at frequencies less than 2.5 hertz.

CONCLUSIONS

Steel structures have an inherent ability to withstand high seismic loading with no major structural failure, as evidenced by the performance of steel structures during past earthquakes. The ability to withstand higher than design basis seismic loads is attributed mainly to the ductile behavior of steel structures, as

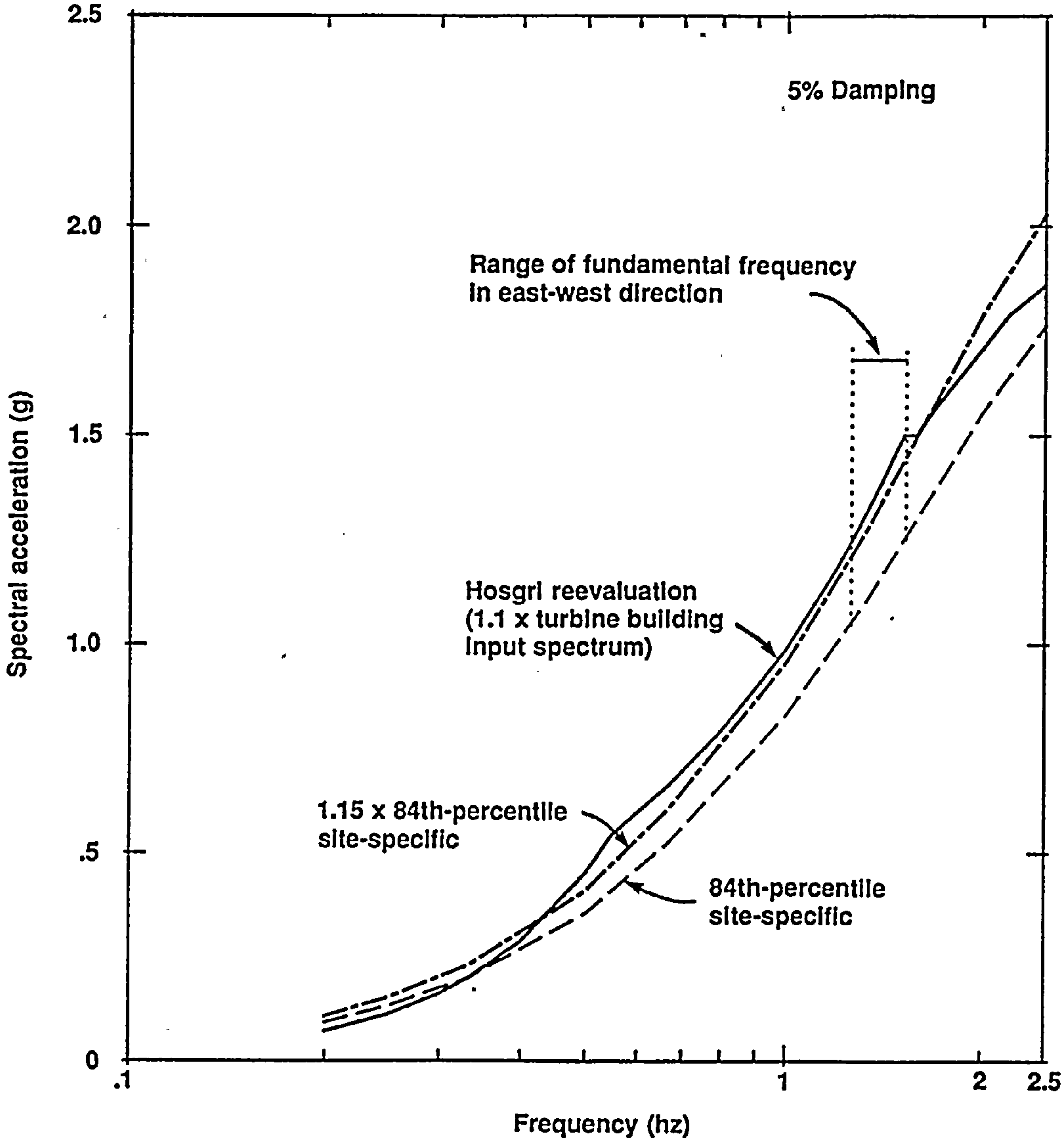

Figure 1

Comparison of spectra below 2.5 hertz applicable to turbine building superstructure evaluation in the east-west direction.

well as to the overall redundancy and consequent redistribution of forces that are not normally considered in the original design process. In the design basis evaluations of Diablo Canyon structures, the enhanced seismic resistance capability due to ductility generally was not considered. However, in a seismic margin assessment such as the Long Term Seismic Program, inelastic energy absorption, where it can be developed, is important to the evaluation of a structure's seismic resistance capabilities.

Plant structures having fundamental modes of vibration in the frequency range below 2.5 hertz are, in general, steel structures that are inherently ductile and, based upon worldwide experience, are expected to perform well during seismic events. These structures were evaluated for the Hosgri earthquake using conservative methods, load combinations, and acceptance criteria, and an adequate seismic margin was obtained for each structure evaluated. The seismic margins will remain adequate for a level of ground motion that is 10 to 15 percent higher than the 84th-percentile site-specific horizontal input motion at frequencies less than 2.5 hertz.